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THE AFFINITIES OF GEINITZIA GRACILLIMA[1]

EDWARD C. JEFFREY

(WITH PLATE VIII)

In a recently published memoir in collaboration with Dr. ARTHUR HOLLICK, the writer has shown that there is good anatomical evidence for regarding numerous mesozoic conifers, which have in the past, from a consideration of their external habit alone, been considered to belong to the Taxodineae or Cupressineae, as in reality appertaining to the araucarian tribe of the Coniferales. In the memoir in question,[2] disjoined leafy twigs and more or less fragmentary relics of cones were described anatomically. In the case of the vegetative twigs it was shown that the anatomical structure was entirely araucarian, and similar evidence was somewhat less conclusively given in the case of the cones. Unfortunately, it was not possible in any of the Kreischerville material to investigate the woody axis of a cone, which would obviously furnish the clearest evidence as to the true affinities of the reproductive branches of the Kreischerville material. The cone scales alone, although furnishing in the opinion of the present writer ample evidence of their araucarian relationships, might by those less experienced in the details of coniferous anatomy still be considered as belonging to strobili of the Taxodineae or Cupressineae. Happily another cretaceous deposit has finally furnished the much to be desired testimony, which apparently puts beyond all possible question the araucarian affinities of the cretaceous remains, which have in the past been referred by purely systematic paleobotanists to the living genus *Sequoia*.

The material on which the present article is based was derived from the Matawan Formation, which clearly overlies the Raritan or Upper Potomac beds from which the Kreischerville material was obtained. Various writers have recorded the abundance of cones of *Sequoia gracillima* in the clays of the coastal bluffs of Cliffwood, New Jersey.[3] Through the kindness of Dr. HOLLICK and particularly of Mr. E. W. BERRY of the Geological Department of Johns Hopkins University, the present writer has received from time to time numerous specimens of this species. Unfortunately all of these were either too thoroughly impregnated with iron pyrites or in too bad a condition of preservation to yield any satisfactory evidence when examined microscopically. After repeated personal visits to the Cliffwood bluffs, the writer was at last rewarded in the spring of 1909 by the discovery of a single cone in which the axis was in a good condition of preservation. The figures in the present article, with the exception of the first, are made from the preparations of this cone.

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[1] Contributions from the Phanerogamic Laboratories of Harvard University, no. 31.

[2] HOLLICK, ARTHUR, and JEFFREY, E. C., Studies of cretaceous coniferous remains from Kreischerville, New York. Mem. N.Y. Bot. Gard., no. III. May 1909.

Fig. 1 shows the surface of a pyritized cone of *Sequoia gracillima*, so-called, from the two opposite flattened surfaces. In *a* is shown the best preserved surface of the cone, while in *b* the hexagonal outlines of the cone scales, and often their surface as well, are obscured by incrustations of the iron pyrites, which infiltrate the substance of the cone itself. In cones showing a better condition of preservation than is generally found in the Cliffwood material, the center of the peltate scales is marked by a profound depression.

Fig. 2 reproduces a transverse section of the peduncle of the well preserved specimen described above. Higher up, the axis of the cone is not so well preserved, being somewhat flattened and considerably more impregnated with granules of iron pyrites. The peduncular portion, however, is in an admirable condition of preservation, even the soft tissues of the phloem and the cortex being clearly recognizable. The pith, which appears in the center of the figure, is characterized by the presence of the same sclerotic nests, composed of stone cells, described in the memoir of Dr. HOLLICK and the present writer, cited above, for the vegetative twigs of a number of conifers which are now known to be of araucarian affinities on the basis of their microscopic structure. Outside the pith is the well developed woody cylinder, which is succeeded by a zone of well preserved phloem of about a third its diameter. External to the phloem lies an irregular and partly destroyed cincture, representing the cortex. The magnification is not sufficient to show that in the cortex there are sclerotic cells similar to those found in the pith.

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[3] NEWBERRY, J. S., Flora of the Amboy clays. *pl. 9. figs. 1–3.* 1896; BERRY, E. W., Flora of the Matawan Formation. Bull. N.Y. Bot. Gard. **3**:no. 9. 1903; BERRY, E. W., Additions to the flora of the Matawan Formation. Bull. Torr. Bot. Club **31**:Feb. 1904.

Fig. 3 shows the structure of the higher part of the cone as seen in longitudinal section. Centrally lies the medullary tissue, largely occupied by stone cells. Near the region of the wood the sclerotic aggregations give place to thin-walled parenchymatous elements. The wood is crossed on the right side of the figure, which shows it in a good condition of preservation, by shallow medullary rays from one to three or four cells in height. The rays, as seen in the transverse and the longitudinal radial sections, are uniseriate. The broad, so-called fusiform, rays found in the pinelike Abietineae are entirely absent. Part of the phloem adheres to the surface of the wood on the right, while on the left both phloem and cortex are absent.

Fig. 4 shows a detailed longitudinal section of part of the pith. The stone cells, with their layered and laminated walls, can be seen intermingled with the thin parenchymatous elements, which constitute the rest of the medullary tissues. The lamination of the walls of the stone cells is to be regarded as the result of the conditions of fossilization, as these cells in similar material from the Kreischerville deposits, in the best preserved twigs, show no indication of lamination.

Fig. 5 shows a transverse section of part of the lower region of the cone axis. The phloem and xylem are both present and in a good condition of preservation. The former occupies the upper part of the figure and is obviously not of the type found in the Cupressineae and Taxodineae (Sequoiineae), since the striking alternating stripes of hard bast fibers, which are characteristic of the phloem of the two coniferous tribes just mentioned, cannot be seen. A zone of decay marks the position of the cambium. Below this region appears the wood, composed of rather small tracheids. The rays can scarcely be made out, since they are composed of smooth thin-walled cells, which very readily collapse.

In the wood on the extreme right and left and radially nearer the right center, are seen dark patches, which on superficial examination might appear to be the resin cells, characteristic of the wood of the Cupressineae and Taxodineae. An attentive microscopic examination of these, however, shows them to be clusters of black crystals of iron pyrites contained in the tracheids of the wood.

Fig. 6 illustrates the structures of the wood as seen in longitudinal section. Toward the left can be seen the cells of the pith, while to the right of these can be made out the ringed and spiral elements of the primary wood. Further to the right, and occupying over half of the field, is part of the secondary wood. The elements of the wood are narrow and are occupied by pits which in no case are contiguous or in more than a single row. With the restricted conception of araucarian woods which has prevailed almost until the present time, pitting of this character would not be regarded as indicative of araucarian affinities. As the result of recent investigations into the structure of mesozoic conifers, we now know that the wood genus *Araucarioxylon* Kraus does not cover all the araucarian ligneous types of the past. This genus is characterized by alternating or flattened pits on the radial walls of the tracheids, by smooth-walled ray cells, and incidentally by the absence of resin canals formed as a result of wounding. As has been pointed out by the present author in the memoir on the Kreischerville conifers and in other publications there cited, there are two other araucarian wood types in the Mesozoic, namely *Brachyoxylon* and *Araucariopitys*. In the former the pits are often of the flattened or alternating character found in the *Araucarioxylon* type, but likewise are as often neither alternating nor flattened. Further, *Brachyoxylon* differs from *Araucarioxylon* in the formation of resin canals as the result of wounding, and resembles it in the possession of smooth-walled ray cells. Writers on cretaceous plants in general have failed to distinguish *Brachyoxylon* from the *Araucarioxylon* type. In *Araucariopitys* we find, in addition to the pitting and wound reactions of *Brachyoxylon*, the strongly pitted ray cells which are characteristic of the Abietineae. This enumeration of araucarian woods, however, is not exhaustive, for recently a new type has been described[4] in which the alternating or flattened pitting, which on the former understanding of the Araucarineae was characteristic of the wood of this coniferous stock, is entirely absent. Thus we come to the paradox of an araucarian wood without araucarian pitting. Quite recently Miss GERRY has shown[5] that the essence of the araucarian ligneous type is the absence of the bars of Sanio in the tracheids, and not necessarily the mode of arrangement or the shape of the radial pits of the tracheids.

With the citation of recent investigations on coniferous woods, we are now in the position to consider the affinities of our cone axis. It has been pointed out in the foregoing paragraph that the cone under consideration had tracheids with unapproximated, unflattened, and non-alternating pits. Under the former conceptions as to the affinities of coniferous woods, our axis would certainly have been placed with *Cedroxylon* or even *Cupressinoxylon*, rather than with the Araucarineae. The smooth walls of the ray cells exclude our axis from the ligneous genus *Cedroxylon*, which properly conceived is characterized by the strongly pitted character of the medullary ray parenchyma, as has recently been insisted upon by GOTHAN. The wood of the cone axis under discussion is, as has been indicated above, in parts in an admirable condition of preservation, and it has been accordingly possible to ascertain definitely that the bars of Sanio are quite absent. This important criterion brings our wood under the Araucarineae in the broadest sense, and among the numerous ligneous types which are now known to have belonged in this formerly very varied and comprehensive coniferous tribe. Among the known types of araucarian woods, it obviously falls into the genus *Paracedroxylon* of SINNOTT.

Conclusions

It is apparent from the description of the cone axis of the supposed species of *Sequoia* known as *S. gracillima*, given in the foregoing paragraphs, that our specimen cannot belong in any way to the genus as at present anatomically characterized. For in the very important particulars of wood structure, organization of the phloem, as well as the constitution of the pith and cortex, it differs absolutely from all existing members of the Cupressineae and Taxodineae. It is equally clear, from a consideration of all the features of histological structure just indicated, that the cone axis under discussion belongs with those Araucarineae of the more primitive type which became extinct with the close of the Mesozoic period. There remains, however, one point to be elucidated. It has been shown in the memoir on the conifers of Kreischerville, frequently cited above, that the vegetative twigs known as *Sequoia Reichenbachii* had structure of the *Brachyoxylon* type, that is, a type intermediate between the true *Araucarioxlyon* type and the *Paracedroxylon* type described by SINNOTT. Our cone, which beyond any reasonable question belongs in the same genus, has not the *Brachyoxylon* type of wood, but on the contrary shows all the features of ligneous organization found in *Paracedroxylon*. It is a somewhat well established principle in coniferous anatomy at the present time, which is applicable to an even wider range of anatomical facts, that the reproductive axes of this order of gymnosperms are apt to perpetuate the structure of ancestral types. For example, the structure of the wood in the *cones* of existing pines is now known to retain the type of wood structure found in the *vegetative* branches of the pines of the Lower Cretaceous. Applying this principle to the cone axis at present under consideration, it is rendered probable that the *Paracedroxylon* type was characteristic of araucarian vegetative twigs representing the ancestral forms from which the so-called cretaceous sequoias were derived. We have thus another and independent argument for the thesis maintained for some years by the present author, in opposition to the received view of most other writers on the conifers, namely, that the Auracarineae characterized by the *Araucarioxylon* type of wood cannot be regarded as primitive members of the stock, but that the *Brachyoxylon*, *Araucariopitys*, and *Paracedroxylon* araucarian types are all older than *Araucarioxylon* and connect it in one way or another with the type of wood found in the

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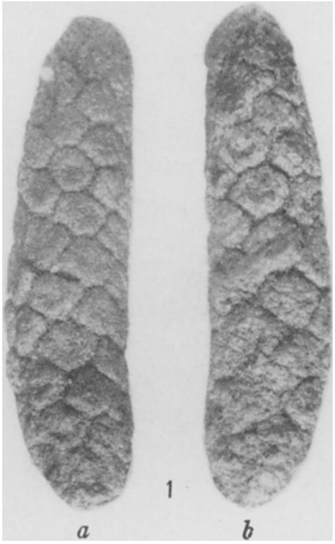
[4] SINNOT, E. W., *Paracedroxylon*, a new type of araucarian wood. Rhodora **11**:165–173. 1909.

[5] GERRY, ELOISE, The distribution of the "bars of Sanio" in the Coniferales. Annals of Botany **24**:119–124. 1910.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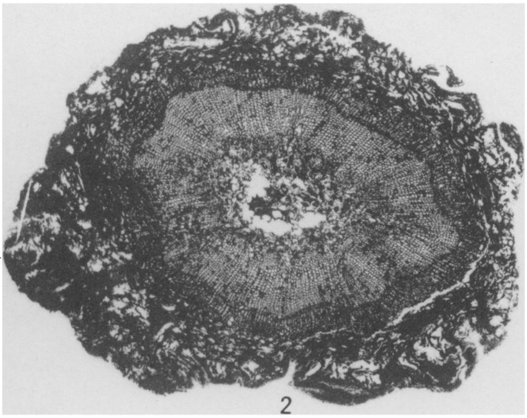
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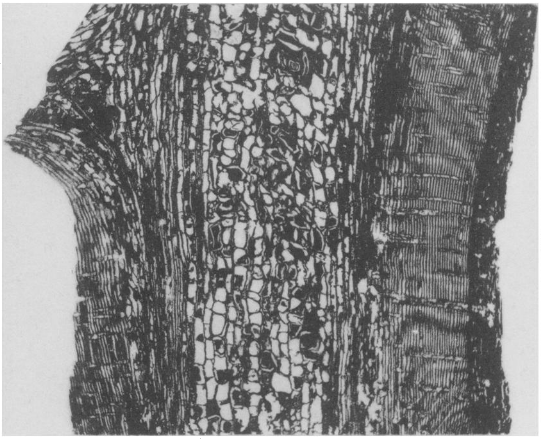
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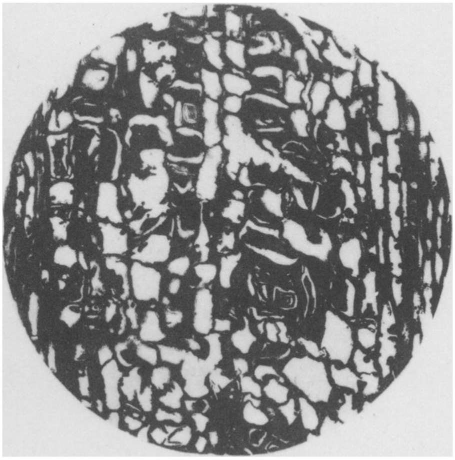
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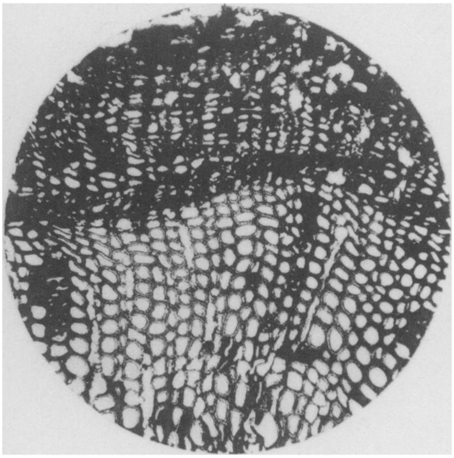
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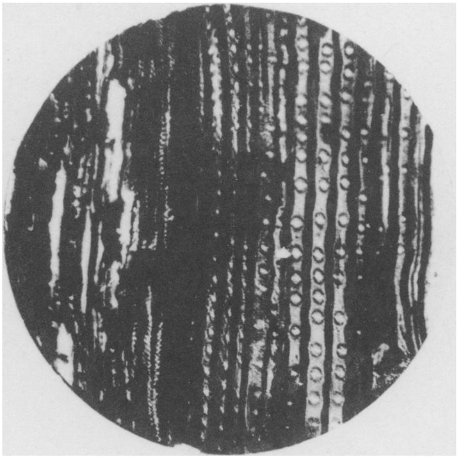
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JEFFREY on GEINITZIA

Abietineae, particularly the older Abietineae, of the *Pinus* type. The discovery of an ancient pinelike conifer, *Prepinus* Jeffrey, with generalized short shoots bearing many spirally arranged leaves, characterized by the possession of fibrovascular bundles with well developed centripetal wood of the archigymnospermous type, as well as the details of organization found in the leaves of certain *Cordaites*, appears to make it quite clear that we must look in the direction of the Abietineae, rather than in that of the Araucarineae, for the primitive representatives of the Coniferales.

Summary

1. *Sequoia gracillima*, so-called, cannot be regarded as belonging to the living genus to which, on its superficial characters, it has been referred.

2. It is an araucarian conifer, and in accordance with accepted principles of nomenclature should in future be referred to the genus *Geinitzia*.

3. The structure of the cone axis in the so-called *Sequoia gracillima* (*Geinitzia gracillima*) vouches for the accuracy of the reference of detached cone scales of species of *Geinitzia*, and other araucarian conifers of similar type from the Lower Cretaceous, to araucarian affinities.

4. The structure of the cone axis of *Geinitzia gracillima*, being less like the *Araucarioxylon* type than that found in the vegetative twigs of representatives of the genus from the Lower Cretaceous, urnished additional and independent evidence for the derivation of the araucarian stock from an ancestry essentially resembling the existing Abietineae.

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EXPLANATION OF PLATE VIII

Fig. 1.—A cone of *Geinitzia gracillima*, slightly reduced, viewed from opposite sides.

Fig. 2.—Transverse section of the peduncle of the cone of *G. gracillima*. ×40.

Fig. 3.—Longitudinal section through a higher region of the same cone. ×40.

Fig. 4.—Longitudinal section through the pith of the same. ×80.

Fig. 5.—Transverse section of the lower region of the cone axis. ×180.

Fig. 6.—Longitudinal radial section of the wood of the cone. ×180.